FORM PTO-1390 (Modified) (REV 11-2000) U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE **TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371**	ATTORNEY'S DOCKET NUMBER **L9289.01146**
	U.S. APPLICATION NO. (IF KNOWN, SEE 37 CFR **09/857328**

INTERNATIONAL APPLICATION NO. **PCT/JP00/06849**	INTERNATIONAL FILING DATE **October 3, 2000**	PRIORITY DATE CLAIMED **October 8, 1999**

TITLE OF INVENTION

RADIO BASE STATION APPARATUS AND RADIO TRANSMISSION METHOD

APPLICANT(S) FOR DO/EO/US

Kazuyuki MIYA

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.

2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.

3. ☒ This is an express request to begin national examination procedures (35 U.S.C. 371(f)). The submission must include itens (5), (6), (9) and (24) indicated below.

4. ☐ The US has been elected by the expiration of 19 months from the priority date (Article 31).

5. ☒ A copy of the International Application as filed (35 U.S.C. 371 (c) (2))

     a. ☐ is attached hereto (required only if not communicated by the International Bureau).

     b. ☒ has been communicated by the International Bureau.

     c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).

6. ☒ An English language translation of the International Application as filed (35 U.S.C. 371(c)(2)).

     a. ☒ is attached hereto.

     b. ☐ has been previously submitted under 35 U.S.C. 154(d)(4).

7. ☐ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371 (c)(3))

     a. ☐ are attached hereto (required only if not communicated by the International Bureau).

     b. ☐ have been communicated by the International Bureau.

     c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.

     d. ☐ have not been made and will not be made.

8. ☐ An English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).

9. ☒ An oath or declaration of the inventor(s) (35 U.S.C. 371 (c)(4)).

10. ☐ An English language translation of the annexes of the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371 (c)(5)).

11. ☐ A copy of the International Preliminary Examination Report (PCT/IPEA/409).

12. ☒ A copy of the International Search Report (PCT/ISA/210).

Items 13 to 20 below concern document(s) or information included:

13. ☒ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.

14. ☒ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.

15. ☐ A **FIRST** preliminary amendment.

16. ☐ A **SECOND** or **SUBSEQUENT** preliminary amendment.

17. ☐ A substitute specification.

18. ☐ A change of power of attorney and/or address letter.

19. ☐ A computer-readable form of the sequence listing in accordance with PCT Rule 13ter.2 and 35 U.S.C. 1.821 - 1.825.

20. ☐ A second copy of the published international application under 35 U.S.C. 154(d)(4).

21. ☐ A second copy of the English language translation of the international application under 35 U.S.C. 154(d)(4).

22. ☐ Certificate of Mailing by Express Mail

23. ☒ Other items or information:

     Claim for Priority with PCT/IB/304
     PCT/IB/308
     PCT/RO/101

PCTUS1/REV03

U.S. APPLICATION NO. (IF KNOWN, SEE 37 CFR) 09/857328	INTERNATIONAL APPLICATION NO. PCT/JP00/06849	ATTORNEY'S DOCKET NUMBER L9289.01146

24. The following fees are submitted:.	CALCULATIONS PTO USE ONLY

BASIC NATIONAL FEE (37 CFR 1.492 (a) (1) - (5)) :

☐ Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO $1000.00

☒ International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO $860.00

☐ International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO $710.00

☐ International preliminary examination fee (37 CFR 1.482) paid to USPTO but all claims did not satisfy provisions of PCT Article 33(1)-(4) $690.00

☐ International preliminary examination fee (37 CFR 1.482) paid to USPTO and all claims satisfied provisions of PCT Article 33(1)-(4) $100.00

ENTER APPROPRIATE BASIC FEE AMOUNT =	**$860.00**

Surcharge of **$130.00** for furnishing the oath or declaration later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492 (e)).	**$0.00**

CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE		
Total claims	7 - 20 =	0	x $18.00	$0.00	
Independent claims	4 - 3 =	1	x $80.00	$80.00	
Multiple Dependent Claims (check if applicable).			☐	$0.00	

TOTAL OF ABOVE CALCULATIONS =	**$940.00**	

☐ Applicant claims small entity status. (See 37 CFR 1.27). The fees indicated above are reduced by 1/2.	**$0.00**	

SUBTOTAL =	**$940.00**	

Processing fee of **$130.00** for furnishing the English translation later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492 (f)). +	**$0.00**	

TOTAL NATIONAL FEE =	**$940.00**	

Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31) (check if applicable).	☒	**$40.00**	

TOTAL FEES ENCLOSED =	**$980.00**	

Amount to be: refunded	$
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a. ☒ A check in the amount of ___$980.00___ to cover the above fees is enclosed.

b. ☐ Please charge my Deposit Account No. _____ in the amount of _____ to cover the above fees. A duplicate copy of this sheet is enclosed.

c. ☒ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. ___19-4375___ A duplicate copy of this sheet is enclosed.

d. ☐ Fees are to be charged to a credit card. **WARNING:** Information on this form may become public. **Credit card information should not be included on this form. Provide credit card information and authorization on PTO-2038.**

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:

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1

DESCRIPTION

RADIO BASE STATION APPARATUS AND RADIO TRANSMISSION

METHOD

5 Technical Field

The present invention relates to a radio base station apparatus and radio transmission method in a digital radio communication system, and more particularly to a radio base station apparatus and radio

10 transmission method in a DS-CDMA (Direct Sequence-Code Division Multiple Access) system.

Background Art

In a mobile communication, the quality of a

15 received signal deteriorates extremely due to fading. One of effective methods for overcoming the fading is a diversity technique. The diversity technique usually uses a plurality of received signals to achieve transmission of high communication quality. For

20 example, when a receiver has two antennas spaced adequately apart from each other, the fading variation on the antenna is independent of each other. Accordingly, provability decreases that the power of signals received by the two antennas decreases at the

25 same time. The diversity technique uses such a principle to prevent the power of a received signal from falling down on a receiver side.

There are, however, various restrictions to achieve the diversity in a communication terminal apparatus such as a mobile station. Therefore, in order to achieve the diversity, which should be achieved

5 originally on a receiver side in the mobile station, on a transmitter side of a base station, a transmit diversity technique has been investigated.

In the transmit diversity, as illustrated in FIG.1, base station 1 transmits signals with the same phase to

10 mobile station 3 using antennas 2a and 2b, and mobile station 3 selects a received signal transmitted from one of the antennas with a power level larger than that of the other signal. Due to the transmit diversity, it is possible to suppress the effect of fading, and to improve

15 the communication quality.

In the transmit diversity, it is thus possible to suppress the effect of fading, and to improve the communication quality, however, it is not possible to provide interfering suppressing effect that is an effect

20 for suppressing the interference in other stations. Particularly in a CDMA system, suppressing interference in other stations enables each station to perform efficient communications, further enables the system capacity to be increased. Therefore, the interfering

25 suppressing effect becomes important.

Disclosure of Invention

It is an object of the present invention to provide a radio base station apparatus and radio transmission method capable of suppressing the effect of fading to improve the communication quality, providing the

5   interfering suppressing effect to other stations, and reducing transmission power per mobile station.

The inventors of the present invention paid attention to a transmission adaptive array antenna (smart antenna) technique for providing the interfering

10   suppressing effect, and achieved a radio base station apparatus and radio transmission method for providing both the fading suppressing effect and interfering suppressing effect, by combining the transmit diversity and transmission adaptive array antenna technique only

15   on a communication channel (including packets) and a control channel for a specific user (FACH (Forward Access Channel) and AICH (Acquisition Indication CHannel)) to which the transmission adaptive array antenna technique is applicable.

20   It is a gist of the present invention that, as illustrated in FIG.2, radio base station apparatus 10 performs the transmit diversity using diversity antennas 11a and 11b, while further performing the transmission adaptive array antenna control, for communication

25   terminal apparatus 20.

Brief Description of Drawings

FIG.1 is a conceptual diagram to explain transmit diversity;

FIG.2 is a conceptual diagram to explain a radio transmission method of the present invention;

5   FIG.3 is a block diagram illustrating a configuration of a radio base station apparatus according to a first embodiment of the present invention; and

FIG.4 is a block diagram illustrating part of a

10   configuration of a radio base station apparatus according to a second embodiment of the present invention.

Best Mode for Carrying Out the Invention

15   Embodiments of the present invention will be described specifically below with reference to accompanying drawings.

(First embodiment)

As transmit diversity schemes, there are two

20   schemes, namely, closed-loop mode transmit diversity and open-loop mode diversity. This embodiment describes a case of the closed-loop mode type of transmit diversity. The present invention is capable of being applied to both an FDD (Frequency Division Duplex) system and TDD (Time

25   Division Duplex) system. The case of the FDD system will be described here. Further, a case will be described that a radio transmission method of the present invention

is applied only to a communication channel (including packets) and a control channel for a specific user (FACH and AICH).

FIG.3 is a block diagram illustrating a configuration of a radio base station apparatus according to the first embodiment of the present invention. The radio base station apparatus has two diversity antennas 101 spaced apart from each other by a distance enabling space diversity, and two processing sequences each having receiver 103 and transmitter 104 provided for a corresponding diversity antenna 101. The switching between transmission and reception for the transmitter and receiver is performed by duplexers 102a to 102c. In addition, in the case of the TDD system, the switching between transmission and reception for the transmitter and receiver is performed by switches, instead of the duplexers.

In an actual communication, since a plurality of channels are multiplexed, a dividing section that divides a received signal for each channel is provided on an output side of a reception RF circuit on a receiver side, while a multiplexing section that multiplexes a plurality of channel transmission signals is provided on an input side of a transmission RF circuit. However, to simplify the explanation, FIG.3 illustrates the configuration for one channel with the dividing section and multiplexing section omitted.

Signals transmitted from a communication terminal apparatus are received at diversity antenna 101 comprised of a plurality of (three in FIG.3) antenna elements 101a to 101c, and output to reception RF

5 circuits 1031a to 1031c through duplexers (Dup) 102a to 102c, respectively. Reception RF circuits 1031a to 1031c perform predetermined radio reception processing (downconverting, A/D conversion, etc.) to respective received signals. In the actual communication, the

10 received signal subjected to the radio reception processing is divided into channel signals.

The received signals subjected to the radio reception processing are respectively output to matched filters (MF) 1032a to 1032c, and are despread using

15 respective spreading codes used in spreading the transmission data on the communication terminal apparatus side. Thus despread signals are output to a reception adaptive array antenna (AAA) (direction-of-arrival estimating circuit) 1033.

20 Reception AAA circuit 1033 (or direction-of-arrival estimating circuit) 1033 performs reception AAA processing or direction-of-arrival estimating processing. These kinds of processing will be described later. Thus processed signal is output to combining

25 circuit 105 for each diversity antenna, combined in combining circuit 105, and obtained as a received signal. Weight information and angle information on the

direction of arrival obtained in the reception AAA processing or direction-of-arrival estimating processing is output to transmission weight calculating circuit 1042 in transmitter 104.

5   Meanwhile, a transmission signal is output to modulating circuit 106 and subjected to digital modulation processing therein. The modulated signal is output to spreading circuit 107 and spread with a predetermined spreading code. At this point, two

10   processing sequences use the same spreading code. The spread signal (transmission signal) is output to transmission weight multiplying section 1043 through transmit diversity circuit 1041 of each transmitter 1045. Transmit diversity circuit 1041 performs transmit

15   diversity processing according to transmit diversity control signals 1 and 2.

Transmission weight multiplying section 1043 multiplies the transmission signal by a respective transmission weight calculated in transmission weight

20   calculating circuit 1042, in each of multipliers 1043a to 1043c provided for corresponding antennas. The transmission signals each multiplied by the transmission weight are output to respective transmission RF circuits 1044a to 1044c, and therein, subjected to predetermined

25   radio transmission processing (D/A conversion, upconverting, etc.). At this point, transmission RF circuits 1044a to 1044c have an input control signal for

closed-loop and/or open-loop transmit power control, and according to the transmit power control signal, control the transmit power. In the actual communication, the transmission signal multiplied by the transmission

5 weight undergoes the transmit power control, and then transmission signals of a plurality of channels are multiplexed. The multiplexed signal undergoes the radio transmission processing. The transmission signals subjected to the radio transmission processing

10 are output to duplexers 102a to 102c, and then transmitted from antenna elements 101a to 101c to a communication terminal apparatus, respectively.

The operation of the radio base station apparatus with the above configuration will be described below.

15 Signals received from diversity antenna 101 are subjected to radio reception processing in reception RF circuits 1031a to 1031b for respective antenna elements 101a to 101c, then despread in matched filters 1032a to 1032c, respectively, and output to reception AAA circuit

20 (or direction-of-arrival estimating circuit) 1033.

Reception AAA circuit (or direction-of-arrival estimating circuit) 1033 obtains weights and directions of arrival for forming an optimal reception radiation pattern, using uplink signals received in respective

25 antenna elements. The weight information and direction-of-arrival information (angle of arrival) is output to transmission weight calculating circuit 1042,

which calculates transmission weights. There are various method as described below for obtaining a weight of reception directivity and direction-of-arrival information from a received signal to calculate a

5 transmission weight.

A first one is such a method that obtains a reception weight in reception AAA processing in reception AAA circuit (or direction-of-arrival estimating circuit) 1033, and using the weight, calculates a transmission

10 weight. For example, there is a method for obtaining the reception weight using beam steering. In addition, the reception AAA processing is described in IEICE TRANS.COMMUN., VOL.E77-B.NO.5 MAY 1994 "Spectral Efficiency Improvement by Base Station Antenna Pattern

15 Control for Land Mobile Cellular systems", entire content of which is expressly incorporated by reference herein.

In this method, as illustrated in FIG.3, in the FDD system, since different frequencies are used between

20 transmission and reception, when the weight obtained in the reception AAA processing is used to calculate a transmission weight, a different radio pattern is obtained at the time of transmission. Therefore, transmission weight calculating circuit 1042 performs

25 regeneration of weights using reception weights obtained in the reception AAA processing. The weight regeneration method is described in also in IEICE

TRANS.COMMUN., VOL.E77-B.NO.5 MAY 1994 "Spectral Efficiency Improvement by Base Station Antenna Pattern Control for Land Mobile Cellular systems", entire content of which is expressly incorporated by reference 5 herein.

In this method, in the TDD system, since the same frequency is used in transmission and reception, transmission weight calculating circuit 1042 calculates transmission weights using the weights themselves 10 obtained in the reception AAA processing.

A second one is such a method that obtains a reception weight in the reception AAA processing in reception AAA circuit (or direction-of-arrival estimating circuit) 1033, estimates a direction of 15 arrival of an uplink signal from the reception weight, and calculates a transmission weight using the estimated value. In the reception AAA processing, a null direction is set by null steering, and therefore the direction of arrival is not obtained necessarily. 20 Accordingly, using the reception weight obtained in the reception AAA processing, a beam direction with the maximum power of a desired signal is detected, and the direction of arrival is estimated from candidate directions of arrival.

25 After the direction of arrival is thus estimated, the estimated value (angle information) is output to transmission weight calculating circuit 1042, and

according to the estimated value, the circuit 1042 calculates a transmission weight for pointing a beam. Samples of the method for calculating a transmission weight from the obtained estimated value is a method for

5 preparing in advance a table relating an estimated value to a transmission weight and referring to the table after obtaining the estimated value to obtain a transmission weight, and another method for performing beam forming using the obtained estimated value and adaptively

10 obtaining a transmission weight.

A third one is such a method that estimates a direction of arrival of an uplink signal without using a reception weight, and calculates a transmission weight using the estimated value. The method for estimating

15 a direction of arrival of an uplink signal is not limited to a particular one. For example, either method would be used that is described in "Design・Analysis Method Workshop in Antenna・Propagation (No.10)-Adaptive Signal Processing Technique by Array Antenna and High-

20 Resolution Direction of Arrival Estimation Introduction Course-Oct.30,1997".

After the direction of arrival is thus estimated, the estimated value (angle information) is output to transmission weight calculating circuit 1042, and

25 according to the estimated value, the circuit 1042 calculates a transmission weight for pointing a beam. Samples of the method for calculating a transmission

weight from the obtained estimated value are, as in the second method, a method for preparing in advance a table relating an estimated value to a transmission weight and referring to the table after obtaining the estimated value to obtain a transmission weight, and another method for performing beam forming using the obtained estimated value and adaptively obtaining a transmission weight.

Meanwhile, a transmission signal is subjected to digital modulation processing in modulating circuit 106, is spread with a predetermined spreading code (the same code for two diversity antennas) in spreading circuit 107 in spreading circuit 107, and is output through transmit diversity circuit 1041 to multipliers 1043a to 1043c in transmission weight multiplying section 1043.

Transmit diversity circuit 1041 performs transmit diversity using transmit diversity control signals 1 and 2. Specifically, transmit diversity circuit 1041 multiplies the spread transmission signal by a weight indicated by each of transmit diversity control signals 1 and 2.

The weight indicated by each of transmit diversity control signals 1 and 2 is of a phase offset, or phase and power offsets in the closed-loop mode. As the closed loop mode, there are two modes, i.e., a mode for using a phase offset as the transmit diversity control signal, and another mode for using a phase offset and power offset as the transmit diversity control signal. This

embodiment is capable of being applied to both closed-loop modes, in other words, to both case of using a phase offset as the transmit diversity control signal, and of using a phase offset and power offset as the

5 transmit diversity control signal.

In the closed-loop mode, a radio base station apparatus provides antennas (in this case, two diversity antennas each comprised of a plurality of antenna elements) with different phase rotations (for example,

10 90° shit) or different power offsets (for example, 8:2 or 2:8 in power ratio) to perform transmission. The control on the offset is determined by a communication terminal apparatus. In other words, the communication terminal apparatus determines, using signals

15 transmitted from both antennas, an extent of a phase difference between both signals, or extents of a phase difference and power difference therebetween, and transmits the control information to the radio base station apparatus, and according to the control

20 information, the radio base station apparatus performs transmission.

The transmission signal with the offset provided in transmit diversity circuit 1041 is multiplied by a transmission weight in each of multipliers 1043a to 1043c

25 in transmission weight multiplying section 1043. The transmission weight is calculated in transmission weight calculating circuit 1042, as described above, based on

the weight information and angle information obtained in the reception AAA circuit and the direction-of-arrival estimating circuit. The transmission signals each thus multiplied by the transmission weight are

5   subjected to predetermined radio transmission processing in respective transmission RF circuits 1044a to 1044c, and then are transmitted in beam forming state to a communication terminal apparatus. In this case, parallel diversity transmission is performed using two

10   diversity antennas 101 spaced apart from each other by a distance enabling space diversity.

In addition, in the case other than a case of the closed-loop mode, a spread transmission signal is multiplied by the above-mentioned transmission weight

15   in each of multipliers 1043a to 1043c in transmission weight multiplying section 1043.

The radio base station apparatus according to this embodiment is capable, on communication channels and control channels for specific users, of suppressing

20   fading by the space diversity effect and of exhibiting the interfering suppressing effect due to the narrowed spatial directivity. Accordingly, the apparatus is capable of improving communication qualities by suppressing the fading, of performing efficient

25   communications with each communication terminal apparatus, and thereby of decreasing effects on other terminal apparatuses to increase the system capacity.

Further, since the communication qualities are improved, it is not necessary to increase a control amount in the transmit power control, nor to shorten a control cycle. Furthermore, the present invention is effective in shadowing due to the space diversity effect. Since the spatial directivity is narrowed, the apparatus of the present invention is capable of communicating efficiently and of decreasing the transmit power.

In the configuration illustrated in FIG.3, a spread transmission signal is multiplied by a phase offset in the closed-loop mode, and is further multiplied by a transmission weight. The multiplication of the phase offset and of transmission weight may be performed together in a same processing section. In other words, a configuration may be possible in which one multiplying section multiplies a spread transmission signal by a phase offset and by a transmission weight. It is thereby possible to cope with the closed-loop mode without modifying the hardware scale (without increasing the number of multipliers), when the closed-loop mode is applied.

(Second embodiment)

This embodiment describes a case that STTD (Space Time Transmit Diversity) that is an example of the open-loop mode is applied. Also in this case, the present invention is capable of being applied to both the FDD (Frequency Division Duplex) system and TDD (Time

Division Duplex) system.   A case will be described that a radio transmission method of the present invention is applied only to a communication channel (including packets) and a control channel for a specific user (FACH

5   and AICH).

FIG.4 is a block diagram illustrating part of a configuration of a radio base station apparatus according to a second embodiment of the present invention. In FIG.4, the same sections as in the FIG.3 are assigned

10 the same reference numerals as in FIG.3 to omit detailed explanations thereof.

The radio base communication apparatus is provided on a transmitter side with modulating circuit 106 that performs digital modulation processing on a transmission

15 signal, transmit diversity circuit 201 that performs transmit diversity processing on the modulate transmission signal, spreading circuit 202 that spreads the transmission signal subjected to the transmit diversity processing, transmission weight multiplying

20 circuit 1043 that multiplies the spread transmission signal by a transmission weight calculated in transmission weight calculating circuit 1042, and transmission RF circuits 1044a to 1044c that perform predetermined transmission processing on respective

25 transmission signals each multiplied by the transmission weight.

The operation of the radio base station apparatus

with the above configuration will be described below.

The apparatus operates in the same way as in the first embodiment until the apparatus acquires reception weight information or direction-of-arrival information using an uplink signal from a communication terminal apparatus, and calculates a transmission weight in transmission weight calculating circuit 1042 from the reception weight or direction-of-arrival information.

Meanwhile, a transmission signal is output to modulating circuit, and is subjected to digital modulation processing. The digital modulated signal is output to transmit diversity circuit 201. Transmit diversity circuit 201 performs transmit diversity calculation (STTD encode) on the digital modulated transmission signal. In the STTD encode, as signals to be transmitted from another transmission antenna at the same time as every successive two symbols (S1, S2), the calculation is performed to obtain (-S2*, S1*). "*" indicates complex conjugate.

The transmission signal subjected to the transmit diversity calculation is output to spreading circuit 202. Spreading circuit 202 spreads the transmission signal with a predetermined spreading code (the same spreading code for two diversity antennas).

The spread transmission signal is multiplied by a transmission weight in each of multipliers 1043a to 1043c in transmission weight multiplying section 1043. The

transmission weight is calculated in transmission weight calculating circuit 1042, as explained in the first embodiment, based on the weight information and angle information obtained in the reception AAA circuit and

5 the direction-of-arrival estimating circuit. The transmission signals each thus multiplied by the transmission weight are subjected to predetermined radio transmission processing in respective transmission RF circuits 1044a to 1044c, and then are transmitted in beam

10 forming state to a communication terminal apparatus. In this case, parallel diversity transmission is performed using two diversity antennas 101 spaced apart from each other by a distance enabling space diversity.

The radio base station apparatus according to the

15 this embodiment is capable, on communication channels and control channels for specific users, of suppressing fading by the space diversity effect, and further of exhibiting the interfering suppressing effect due to the narrowed spatial directivity. Accordingly, the

20 apparatus is capable of improving communication qualities by suppressing the fading, of performing efficient communications with each communication terminal apparatus, and thereby of decreasing effects on other terminal apparatuses to increase the system

25 capacity. Further, since the communication qualities are improved, it is not necessary to increase a control amount in the transmit power control, nor to shorten a

control cycle. Furthermore, the present invention is effective in shadowing due to the space diversity effect. Since the spatial directivity is narrowed, the apparatus of the present invention is capable of communicating

5 efficiently and of decreasing the transmit power.

In addition, in the open-loop mode, since a communication terminal apparatus does not need to transmit a control signal to a radio base station apparatus, the control can be simplified between the

10 communication terminal apparatus and radio base station apparatus.

The present invention is not limited to the above-mentioned embodiments, and is capable of being carried into practice with various modifications thereof.

15 For example, in the above-mentioned first to second embodiments, a case is described that a receiver of the radio base station apparatus receives signals using an adaptive array antenna, however, the present invention is capable of being applied similarly also to a case that

20 the receiver does not use an adaptive array antenna in receiving signals. Further, in the above-mentioned first to second embodiments, a case is described that transmission and reception on uplink and downlink are performed in the FDD system, however, the present

25 invention is capable of being applied similarity also to a case where transmission and reception on uplink and downlink are performed in the TDD system.

A radio base station apparatus of the present invention comprises two diversity antennas, each comprised of a plurality of antenna elements, spaced apart from each other by a distance enabling space

5   diversity, and transmitters provided for each of the two diversity antennas, where each of the transmitters have a calculating section that calculates a transmission weight from a reception weight or an angle of a direction of arrival obtained by using an uplink signal, and a

10   multiplying section that multiplies a transmission signal spread with a predetermined spreading code by the transmission weight.

According to this configuration, on communication channels and control channels for specific users, it is

15   possible to suppress fading by the space diversity effect, and to exhibit the interfering suppressing effect due to the narrowed spatial directivity. Accordingly, the apparatus is capable of improving communication qualities by suppressing the fading, of performing

20   efficient communications with each communication terminal apparatus, and thereby of decreasing effects on other terminal apparatuses to increase the system capacity. Further, since the communication qualities are improved, it is not necessary to increase a control

25   amount in the transmit power control, nor to shorten a control cycle. Furthermore, the present invention is effective in shadowing due to the space diversity effect.

Since the spatial directivity is narrowed, the apparatus of the present invention is capable of communicating efficiently and of decreasing the transmit power.

In the radio base station apparatus of the present invention with the above configuration, each of the transmitters further have an offset providing section that provides a transmission signal with a phase offset, or a phase offset and a power offset.

According to this configuration, also in the closed-loop mode, on communication channels and control channels for specific users, it is possible to suppress fading by the space diversity effect, and to exhibit the interfering suppressing effect due to the narrowed spatial directivity.

In the radio base station apparatus of the present invention with the above configuration, the multiplying section operates as the offset providing section.

According to this configuration, even when the closed-loop mode is applied as transmit diversity, it is possible to cope with the closed-loop mode without modifying the hardware scale (without increasing the number of multipliers).

In the radio base station apparatus of the present invention with the above configuration, each of the transmitters further have a calculating section that performs transmit diversity calculation on a transmission signal to be subjected to spreading.

According to this configuration, by the transmit diversity in the open-loop mode, on communication channels and control channels for specific users, it is possible to suppress fading by the space diversity effect,

5 and to exhibit the interfering suppressing effect due to the narrowed spatial directivity.

A communication terminal apparatus of the present invention has a feature of performing a radio communication with the above-mentioned radio base

10 station apparatus. It is thereby possible on communication channels to suppress fading by the space diversity effect, to exhibit the interfering suppressing effect due to the narrowed spatial directivity, and to perform more efficient radio communications.

15 A radio transmission method of the present invention comprises the steps of calculating a transmission weight from a reception weight or an angle of a direction of arrival obtained by using an uplink signal, providing a transmission signal spread with a

20 predetermined spreading code with a phase offset, or a phase offset and a power offset, multiplying the transmission signal provided with the phase offset by the transmission weight, and transmitting the transmission signal multiplied by the transmission

25 weight from two diversity antennas, each comprised of a plurality of antenna elements, spaced apart from each other by a distance enabling space diversity.

According to this method, in the closed-loop mode, on communication channels and control channels for specific users, it is possible to suppress fading by the space diversity effect, and to exhibit the interfering

5 suppressing effect due to the narrowed spatial directivity.

A radio transmission method of the present invention comprises the steps of calculating a transmission weight from a reception weight or an angle

10 of a direction of arrival obtained by using an uplink signal, performing transmit diversity calculation on a transmission signal, spreading the transmission signal subjected to the transmit diversity calculation with a predetermined spreading code, multiplying the spread

15 transmission signal by the transmission weight, and transmitting the transmission signal multiplied by the transmission weight from two diversity antennas, each comprised of a plurality of antenna elements, spaced apart from each other by a distance enabling space

20 diversity.

According to this method, in the open-loop mode, on communication channels and control channels for specific users, it is possible to suppress fading by the space diversity effect, and to exhibit the interfering

25 suppressing effect due to the narrowed spatial directivity.

As described above, according to the present

invention, it is possible, on communication channels and control channels for specific users, to suppress fading by the space diversity effect and to exhibit the interfering suppressing effect due to the narrowed

5   spatial directivity.

This application is based on the Japanese Patent Application No.HEI11-287896 filed on October 8, 1999, entire content of which is expressly incorporated by reference herein.

10

Industrial Applicability

The present invention is capable of being applied to a digital radio communication system, and more particularly to a radio base station apparatus and radio

15   transmission method used in DS-CDMA.

CLAIMS

1. A radio base station apparatus comprising:

two diversity antennas, each comprised of a plurality of antenna elements, spaced apart from each

5 other by a distance enabling space diversity; and

transmitters provided for each of said two diversity antennas, each of said transmitters having calculating means for calculating a transmission weight from a reception weight or direction-of-arrival

10 information obtained by using an uplink signal, and multiplying means for multiplying a transmission signal spread with a predetermined spreading code by the transmission weight.

2. The radio base station apparatus according to

15 claim 1, wherein each of said transmitters further have offset providing means for providing a transmission signal with a phase offset, or a phase offset and a power offset.

3. The radio base station apparatus according to

20 claim 2, wherein said multiplying means operates as said offset providing means.

4. The radio base station apparatus according to claim 1, wherein each of said transmitters further have calculating means for performing transmit diversity

25 calculation on a transmission signal to be subjected to spreading.

5. A communication terminal apparatus for

performing a radio communication with a radio base station apparatus, said radio base station apparatus comprising:

two diversity antennas, comprised of a plurality

5 of antenna elements, spaced apart from each other by a distance enabling space diversity; and

transmitters provided for each of said two diversity antennas, each of said transmitters having calculating means for calculating a transmission weight

10 from a reception weight or direction-of-arrival information obtained by using an uplink signal, and multiplying means for multiplying a transmission signal spread with a predetermined spreading code by the transmission weight.

15 6. A radio transmission method comprising the steps of:

calculating a transmission weight from a reception weight or an angle of a direction of arrival obtained by using an uplink signal;

20 providing a transmission signal spread with a predetermined spreading code with a phase offset, or a phase offset and a power offset;

multiplying the transmission signal provided with the offset by the transmission weight; and

25 transmitting the transmission signal multiplied by the transmission weight from two diversity antennas, each comprised of a plurality of antenna elements, spaced

apart from each other by a distance enabling space diversity.

7.   A radio transmission method comprising the steps of:

5   calculating a transmission weight from a reception weight or an angle of a direction of arrival obtained by using an uplink signal;

performing transmit diversity calculation on a transmission signal;

10   spreading the transmission signal subjected to the transmit diversity calculation with a predetermined spreading code;

multiplying the spread transmission signal by the transmission weight; and

15   transmitting the transmission signal multiplied by the transmission weight from two diversity antennas, each comprised of a plurality of antenna elements, spaced apart from each other by a distance enabling space diversity.

ABSTRACT

Only on a communication channel (packets) and a control channel for a specific user (FACH or AICH), radio base station apparatus 10 performs transmit diversity using diversity antennas 11a and 11b, while further performing transmission adaptive array antenna control, for communication terminal apparatus 20.
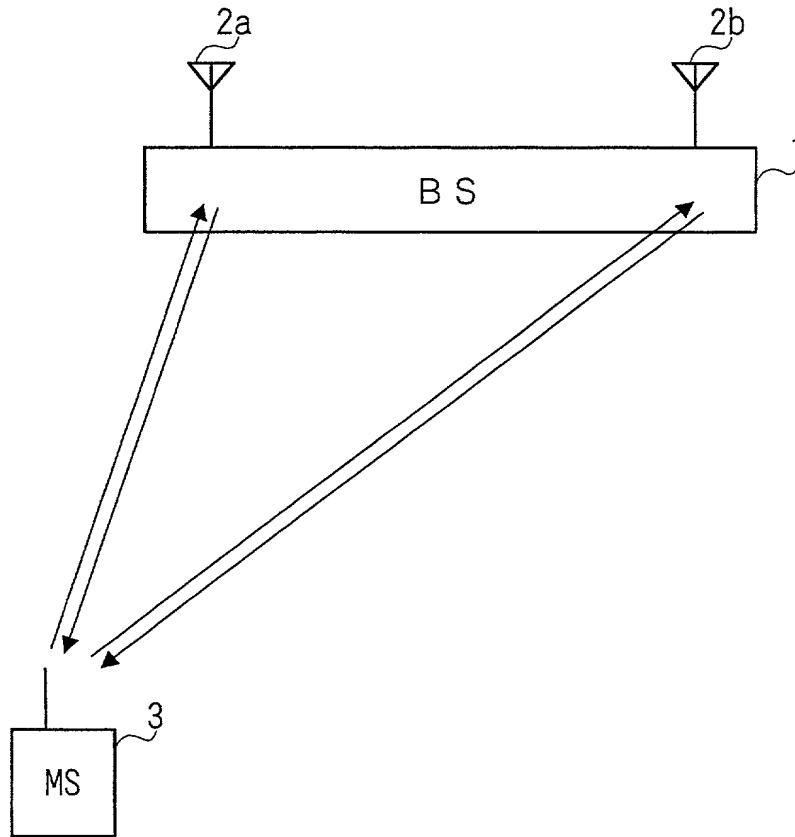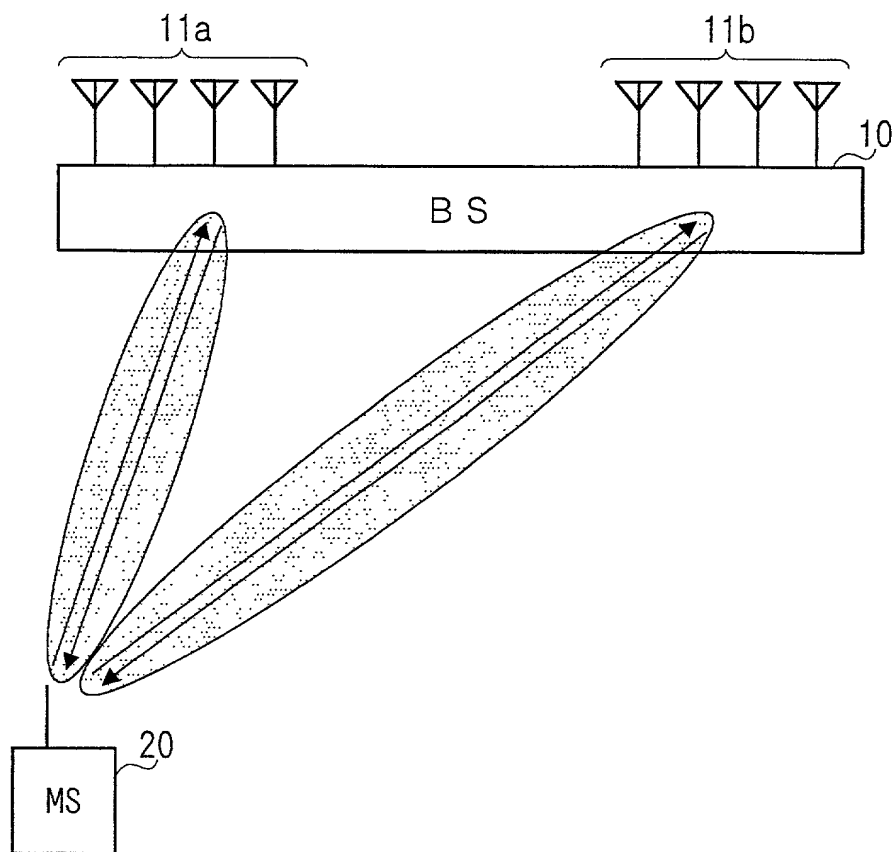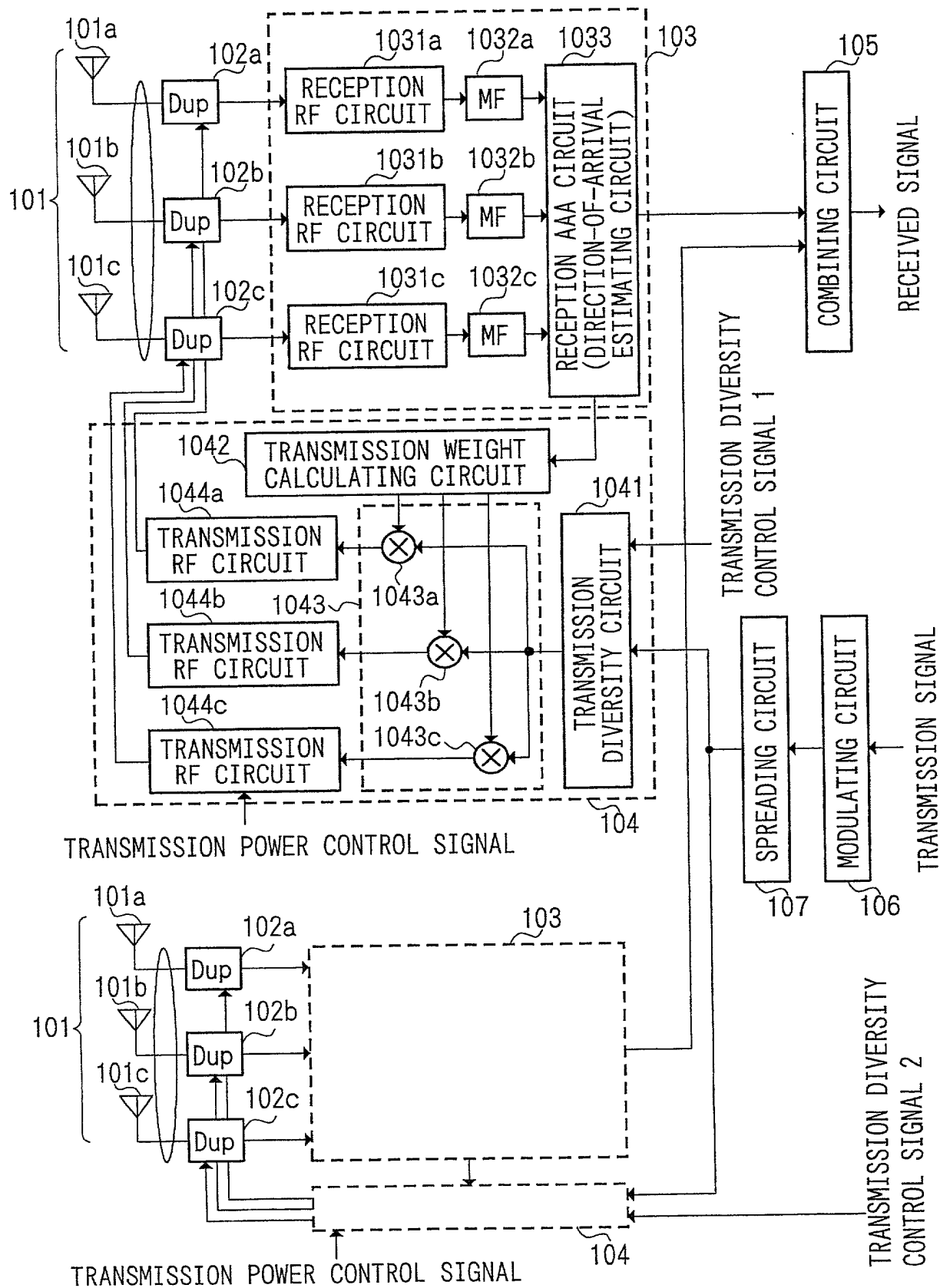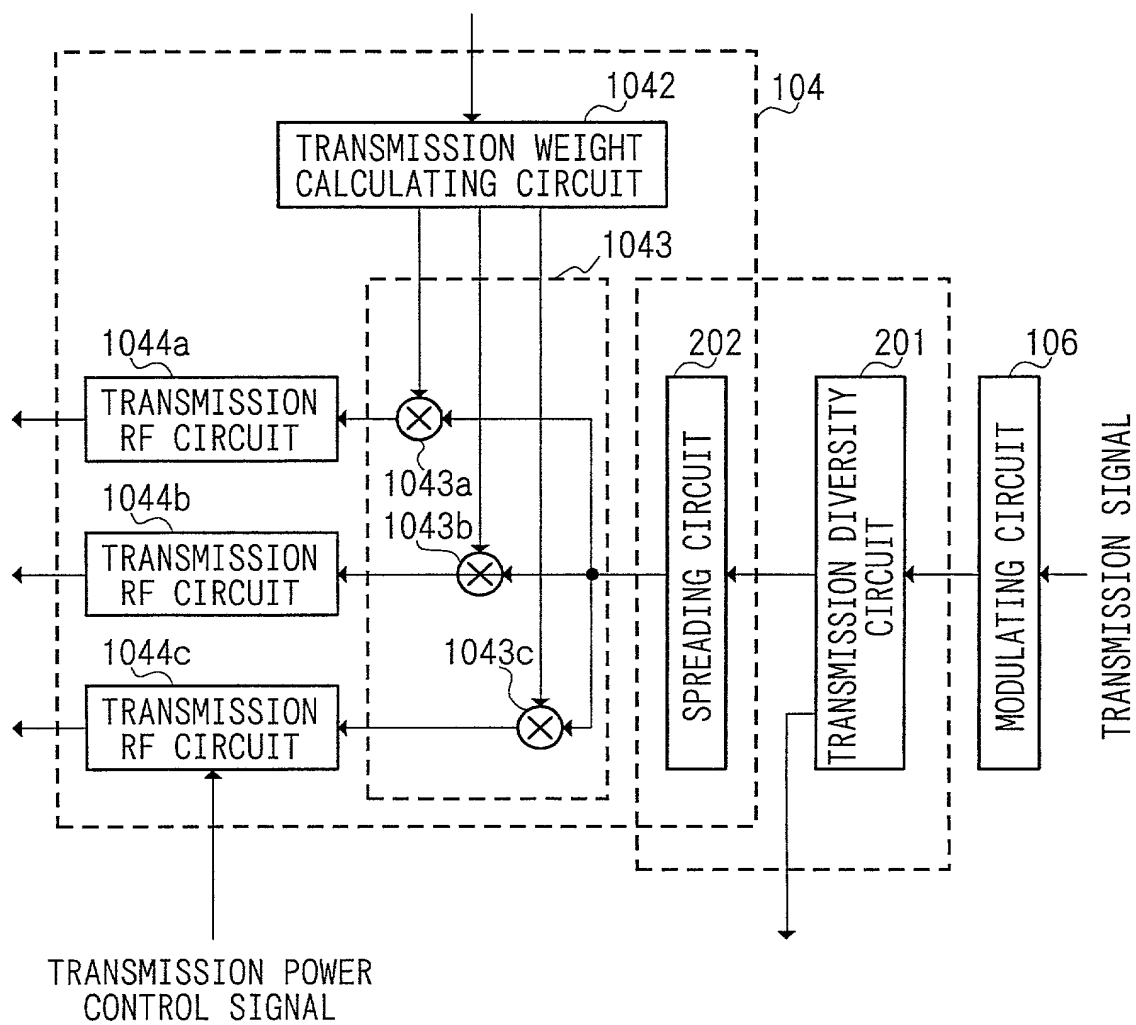
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FIG. 1

FIG. 2

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FIG. 3

FIG. 4

APPLICATION FOR UNITED STATES PATENT
Declaration for Patent Application

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on

the invention entitled: **RADIO BASE STATION APPARATUS AND RADIO TRANSMISSION METHOD**

the specification of which   2 (file no _____)

(check at least one)

3 [x]   is attached hereto

4 [ ]   was filed on _____ as (5) U.S. Application Serial No._____

6 [ ]   and was amended _____
(if applicable)

Use this portion only if you are entering the U.S. National phase based on a PCT International Application designating the U.S.	7 [x]	was filed as PCT international application
	8	Number **PCT/JP00/06849**
	9	on **October 3, 2000**
		and was amended under PCT Article(s) 19 and/or 34
	10	on ——————————————————— (if applicable).
	11	priority date claimed in PCT International Application

JAPAN	**JP11-287896**	**08/October/1999**
(Country)	(Number)	(Day/Month/Year Filed)

I hereby declare that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended, by any amendment referred to above.

I acknowledge the duty to disclose to the United States Patent and Trademark Office all information known to me which is material to patentability in accordance with Title 37, Code of Federal Regulations, §1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, §119 of any foreign application (s) for patent or inventor's certificate listed below and have also identified below any foreign application(s) for patent or inventor's certificate or any PCT international application(s) designating at least one country other than the United States of America filed by me on the same subject matter having a filing date earlier than that of the application(s) on which priority is claimed.

Prior (Foreign) Application(s) any Priority Claims Under 35 U.S.C. 119   Priority Claimed

(Country)	(Number)	(Day/Month/Year Filed)	[ ] Yes	[ ] No
(Country)	(Number)	(Day/Month/Year Filed)	[ ] Yes	[ ] No

12a

Priority Claim(s) from U.S. Provisional Application(s) – I hereby claim the benefit under Title 35, United States Code, §119(e) of any United States provisional application(s) listed below:

12b

Application No.	Day/Month/Year Filed	Application No.	Day/Month/Year Filed

Do not use this portion to identify a PCT application if the parent application is the U.S. National phase of the PCT application	I hereby claim the benefit under Title 35, United States Code, 120 of any United States application(s) or PCT international application(s) designating the United States of America that is/are listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in that/those prior application(s) in the manner provided by the first paragraph of Title 35, United States Code §112, I acknowledge the duty to disclose to the United States Patent and Trademark Office all information known to me to be material to patentability as defined in Title 37, Code of Federal Regulations, §1.56 which became available between filing date of the prior application and the national or PCT international filing date of this application.

13

(U.S. Application Number)	(U.S. Filing Date)	Status (patented, pending, abandoned)

I hereby appoint the following attorneys of the firm of Stevens, Davis, Miller & Mosher, L.L.P. as my attorneys of record with full power of substitution and revocation to prosecute this application and to transact all business in the Patent and Trademark Office:

James E. Ledbetter, Reg. No. 28732; Thomas P. Pavelko, Reg. No. 31689; and Anthony P. Venturino, Reg. No. 31674.

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"I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful statements may jeopardize the validity of the application or any patent issuing thereon.

PAGE 2 OF U.S.A. DECLARATION FORM

14a	Typewritten Full Name of Sole or First Inventor	**Kazuyuki**	**MIYA**
		Given Name Middle Name	Family Name
15a	Inventor's Signature	*Kazuyuki*	*Miya*
16a	Date of Signature	*March 26,*	*2001*
		Month Day	Year
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15b	Inventor's Signature		
16b	Date of Signature		
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14d	Typewritten Full Name of Sole or First Inventor		
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15d	Inventor's Signature		
16d	Date of Signature		
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17d	Residence		
		City State or Province	Country
18d	Citizenship		
19d	Post Office Address (Insert complete mailing address, including country)		

*Note to Inventor: Please sign name on line 15 exactly as it appears in line 14 and insert the actual date of signing on line 16.   If there are more than four inventors, please add a copy of this page for identification and signatures for the additional inventors.

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